DEVICE FOR REMOTE MONITORING OF THE OVERHEAD POWER TRANSMISSION LINE CONDUCTOR STATUS (OPTIONS)

Area of technique

The invention belongs to the remote monitoring of power facility objects, and is designed for obtaining data on status of overhead power transmission line (OHTL) conductor, and transmitting such to an information collection point (dispatch point). Controlled parameters of OHTL conductor status include, in particular, its temperature, current, tension (mechanical breaking load), as well as static and dynamic parameters of conductor's attitude: clearance to the ground, parameters of swing (due to wind), or galloping (auto-oscillations due to even wind effect on conductor with non-symmetric radial ice).

Monitoring results can be used for OHTL mode control aimed on reliable OHTL operation at the maximum usage of its load capacity.

Level of technique

A device is known [1], placed at OHTL conductor, containing temperature sensor and memorizing unit capable to measure conductor's temperature and store the measured values up to reading them using a PC. Limitations of the device [1] are: necessity to remove it from OHTL for reading measurement results, and limited set of parameters measured.

A portable device is known [2] that is a laser range meter capable of measuring distance between OHTL conductor and ground surface in a specified point (clearance to ground). Limitations of the device [2] are: required participation of operator who conducts and logs measurements, and limited set of parameters measured.

A portable device is known [3] that is a stationary system containing a laser range meter installed by OHTL span, that logs static and dynamic parameters of conductor status, including such events like swing and galloping if any. This device is in fact a modification of laser range meter [2], providing for monitoring conductor's dynamic behavior. Limitations of this device include its big size and requirement for permanent setup and service.

Common limitation of devices [1,2,3] is lack of means for transmitting data on conductor parameters measurement results to a control point, and therefore, impossibility to real-time monitor OHTL conductor status.

Known are devices [4] and [5] of real-time OHTL conductor parameters monitoring, equipped with data transmission means.

Device [4] is installed at OHTL tower, and it is a sensor of conductor tension (mechanical load applied to suspension insulator). equipped with means of primary processing, storage and radio transmission of measurements results that provides for OHTL conductors tension real-time monitoring. Out of tension value measured by the device [4] other conductor status parameters can be computed.

Limitation of the device [4] is necessity to setup and maintain a specialized radio communication system, as well as low reliability and accuracy of data obtained. The latest is due to assessment of conductor's condition not via direct measurements of such parameters as temperature and positioning of conductor, but upon analysis of indirect features instead. Thus, conductor's temperature is indirectly assessed upon calculations using data on conductor's tension value,

ambient temperature, wind velocity and conductor's current load as of the moment of measurement. Conductor's positioning and clearance to ground can also be detected indirectly only, using data of conductor position under rated conditions, formulas and relations, describing connection of the monitored conductor tension value with sag.

Selected as a prototype device for remote monitoring of overhead power line conductor [5] contains a housing equipped with a mean for attachment to power line conductor, and located inside the housing power supply and measuring-transmitting module. Measuring-transmitting module of the device [5] includes a control unit, a unit for reception and conversion of conductor status signals, communication and data transmission unit. Output of the unit for reception and conversion of conductor status signals is connected to input of the communication and data transmission unit.

The prototype device is attached to OHTL conductor, operates as an autonomous element of the real-time OHTL conductor status monitoring system, ensuring data transmission via channel of specialized technological information system (it is recommended to setup such system in [5] based on the principles of HF communication via OHTL conductors, involving high voltage connecting modules [6]).

Limitation of the prototype is that special technical applications should be produced and maintained to allow its operation in the monitoring system.

This limitation is conditioned by the following. Device located at OHTL conductor as an autonomous measuring element of monitoring system, requires external means for implementing a function of measuring parameters of conductor status and/or communication with a point collecting measured information. For the prototype, additional special equipment should be introduced in the monitoring system (like, laser range meter [2], [3] and/or HF communication correspondingly), which failure or interruption in operation reduce both reliability of the monitoring system as a whole, and its autonomous measuring element.

Substance of the invention

The objective of invention is to exclude necessity of production and maintenance of specialized technological means for measuring conductor status parameters and/or communication with a point collecting measured information, and, thus improve reliability of the device operation as an autonomous element of OHTL conductor status monitoring.

Subject of the invention (option one) is a device for remote monitoring of OHTL conductor, containing housing equipped with a mean for attachment to power line conductor, and located inside the housing power supply and measuring-transmitting module interfaced with a utility cellular telephony channel.

Subject of the invention (option two) is also a device for remote monitoring of OHTL conductor, containing housing equipped with a mean for attachment to power line conductor, and located inside the housing power supply and measuring-transmitting module equipped with a Global Positioning System signals receiver identifying its three-dimensional coordinates.

Combination of the attributes of each of the above options of the invention allows improving reliability of the device operation as an autonomous element of OHTL conductor status monitoring.

The first option of the invention has a development that the measuring-transmitting module has a control unit, unit of receipt and conversion of conductor status signal, unit of primary processing of obtained information, collection and storage of data, unit of communication and data transmission, while unit of primary processing of obtained information, collection and storage of data is connected to input of unit of communication and data transmission and to output of unit of receipt and conversion of conductor status signal, and interface with a utility cellular telephony channel is introduced in unit of communication and data transmission.

Another development of the first option of the invention is that a Global Positioning System signals receiver identifying its three-dimensional coordinates is introduced in the measuring-transmitting module.

This allows monitoring static and dynamic parameters of conductor positioning parameters keeping the reliability of the device's autonomous operation.

The second option of the invention has a development that the measuring-transmitting module has a control unit, unit of receipt and conversion of conductor status signal, unit of primary processing of obtained information, collection and storage of data, unit of communication and data transmission, while unit of primary processing of obtained information, collection and storage of data is connected to output of unit of receipt and conversion of conductor status signal and to input of unit of communication and data transmission, and Global Positioning System signals receiver identifying its three-dimensional coordinates is introduced in unit of receipt and conversion of conductor status signal.

The second option of the invention has another development that the measuring-transmitting module is interfaced with a utility cellular telephony channel.

This allows additional improving the reliability of the device's autonomous operation on the second option of invention.

Both options have additional developments:

- unit of receipt and conversion of conductor status signal contains a sensor of current values in conductor;
- unit of receipt and conversion of conductor status signal contains a sensor of conductor temperature that may be mounted in the mean of the housing attachment to power line conductor;
- unit of communication and data transmission is equipped with means of receipt of data inquiry signals, setting digital data, and unauthorized access protection.

This would provide required sets of monitored parameters of conductor status and operational abilities of device in particular device options.

Both options of the invention have other developments that power supply can be provided as a battery chargeable from power line current and/or additionally provided solar battery.

This allows additional improving the reliability of the device's autonomous operation.

Brief description of drawings

Fig. 1 shows functional pattern of the device considering its development; Fig. 2 shows general view of the device installed at OHTL conductor.

Execution of the invention

Fig. 1 shows:

1 – power supply,
2 – control unit,
3 – unit of receipt and conversion of conductor status signal,
4 – unit of primary processing of obtained information, collection and storage of data,
5 – unit of communication and data transmission,
6 – OHTL conductor.

Unit 1 can be done as a battery chargeable from OHTL current, and/or solar battery, in this case to be included in the device's set (not shown on Fig. 1).

Unit 2 controls operation of units 3, 4, 5, and device as a whole.

Unit 3 includes:

7 – sensor of parameters of current in conductor 6,
8 – sensor of temperature of conductor 6,
9 – Global Positioning System signals receiver identifying its three-dimensional coordinates (GPS receiver).

Fig. 2 shows:

10 – housing of device,
11 – means of attachment of housing 10 to conductor 6,
12 and 13 – antennas of unit 5 and receiver 9,
as well as conductor 6 and sensor 8 mounted inside means 11 (sensor 7 on Fig. 2 is not shown, and sensor 8 consists of two parts).

Unit 4 is connected to the output of unit 3 and input of unit 5, and it performs primary processing of obtained information, collection and storage of data.

Unit 5 ensures communication and data transmission to the point of measurements collection.

Units 2, 4 and 5 can be executed on a basis of microprocessor technique with a program control, and be structurally combined with unit 3 in a united measuring-transmitting module 14.

Interface 15 with utility cellular telephony channel that module 14 is equipped with, is shown on Fig. 1 within unit 5 set. Unit 5 can be also equipped with means of receipt of data inquiry signals, setting digital data, and unauthorized access protection, not shown on Fig. 1.

Sensor 7 operates as current transformer and can be structurally executed similar to, for example, a clamp-on meter.

Sensor 8 can be executed on a basis of one or two thermocouples, incorporated (see Fig. 2) into means 11 of housing 10 attachment to conductor 6.

Receiver 9, which module 14 is equipped with, is shown on Fig. 1 within unit 3. Receiver 9 can be executed on a basis of commercially available GPS receiver chip.

Antennas 12 and 13 are connected to unit 5 and receiver 9 accordingly, and ensure their operations.

The device is directly attached to OHTL conductor in a span – preferably in span middle, or at max. sag point, and operates as below.

Using sensor 8, unit 3 receives analogue electric signal corresponding to temperature of conductor 6, converts it into digital data and transmits to unit 4 where it is stored, collected and primary processed.

Using sensor 7, unit 3 receives analogue electric signal corresponding to current of line (carrying data on current value, frequency, phase etc.), converts it into digital data and transmits to unit 4 where it is stored, collected and primary processed.

Using receiver 9, unit 3 receives signals from Global Positioning System, GPS satellites. [7]. Receiver 9 is equipped with analyzer of GPS signals that out of their relative delays (approximately once per microsecond) acquires the receiver's position in three-dimensional coordinate system. Data on receiver's 9 (and, therefore, conductor's 6) coordinates pass from unit 3 to unit 4, where it is, similarly with other parameter's, stored, collected and primary processed. Certain increase of the receiver's resolution capacity is ensured in this case, that allows measuring relatively small moves of OHTL conductor using GPS system initially designed for mobile objects' positioning. Such effect is due to receiver's long-time receipt of GPS signals being basically stationery, before any intense swings occur.

From unit 4 the data pass to unit 5 ensuring transmission to the control point of status data (temperature, current and attitude) of the conductor.

In those options of the invention execution where module 14 is equipped with a mean 15 (modem), data transmission is conducted via utility cellular telephony channels. Data may be transmitted periodically with a, for instance, 15 minute interval, or on inquiry from the information collection and processing point. In a latter case, unit 5 should have means of receipt of data inquiry signals and may be connected to unit 2 with a circuit 16 initiating operation of the device.

At the information collection and processing point, receipt of data and control signals transmission (inquiry for transmission and settings data) can either be executed using a specialized device, or personal computer, which interface with communication channel may be arranged via regular telephone line using a standard modem.

The offered device utilizes the known utility means (GPS signals and cellular telephone channels) for solving specific task of monitoring OHTL conductor's parameters status.

The cellular communication here is used not on its direct purpose (providing telephony for mobile subscribers), but for ensuring telephone connection with an object located under high voltage conditions. Technical effect of cellular communication usage in the invention is that there is no necessity to create and maintain both means of high voltage decoupling, and specialized communication system. Plus, reliability of the device's autonomous operation grows, since operation of utility telephone network (including cellular) usually continues in case of failure or interruption of separate lines, high voltage substations, power plants, and even power utilities.

It is important to mention that known from, for example [8], usage of mobile telephony in household appliances remote control, does not provide for data transmission directly from elements (sensors) installed on current conducting (moreover high voltage) parts of equipment, and, therefore, is not accompanied with the above technical result. In [8] a different task is solved and a different technical result is achieved (usage of ready and available mean – mobile phone, as a remote system terminal), based on such property of mobile phones as a display suitable for indication of control instructions and results of household appliances control.

Inventive level of the offer is also confirmed by [9], describing a system of monitoring parameters of electric power objects in hard-to-reach locations (on high voltage and rotating parts of equipment), while not considering usage of cellular telephony channels for this purpose.

Industrial applicability

The invention's applicability presumes meeting at least one of the two requirements to device's location on OHTL:

- It should be inside of at least one mobile operator coverage area.
- It should provide for receipt of at least 3 GPS constellation satellites signals at a time, out of the total count of 21 orbital objects.

Currently the first requirement is mostly met in developed areas with high population density, and the second one (due to large total number of GPS constellation orbital objects, evenly located on orbit around Earth) – in virtually any point of Earth surface.

Meeting the first requirement allows application of the invention in its first execution option, and meeting the second – in the second one. In both cases, technical result of the invention is ensured – improving reliability of the device's autonomous operation.

On the other hand, choice of the invention execution option may be determined by economic considerations and priority task for OHTL conductor status monitoring, depending, for instance, on presence of icy critical sections, strength and direction of prevailing wind at OHTL route, load on line.

Thus, depending on specific OHTL conditions, the offered device may be executed in two general options, each providing for appropriate development in the future with further increase of reliability and operative autonomy, should both of the above requirements be met at the device's location.

Information sources

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